

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:

Igarashi et al.

Group Art Unit: 2879

Application No.: 10/566,723

Examiner: Thomas A. Hollweg

Filed: February 2, 2006

For: ORGANIC ELECTROLUMINESCENT DEVICE

DECLARATION UNDER 37 C.F.R. §1.132

Sir:

I, Toshihiro Ise, a citizen of Japan, hereby declare and state that:

1. I received a Doctor's Degree in Chemistry from Tohoku University, Graduate School of Science in March 1999;
2. I joined Fuji Photo Film Co., Ltd. in April 1999, and have been engaged in the research and development of organic electroluminescence devices since that time; and
3. I am a researcher of the subject matter disclosed and claimed in the above-identified patent application; and
4. I am familiar with the Office Action dated March 6, 2008, and understand the Examiner's rejections therein.

In order to show the difference between the instant invention and the invention described in Akiyama et al. and demonstrate the unexpected superiority of the present invention, the following comparative experiment was conducted under my supervision.

EXPERIMENT

Preparation of EL Device of Example 1 described in Akiyama et al.

A coating solution was prepared to solve 0.02 mg of fac-Tris(2-phenylpyridine) iridium, 0.10 mg of Rhodamine 101, 15.88 mg of Poly(N-vinylcarbazole), and 4.0 mg of PBD in 1.98 g of Chloroform. The prepared coating solution was coated on a cleaned ITO substrate by a spin coating method under the conditions of 3,000 rpm and a coating time of 30 seconds and dried at room temperature (25 °C) for 30 minutes to form a thin layer. A pattern mask (having a pattern giving a light-emitting area of 4 mm by 5 mm) was put on the thin film, and silver and magnesium were vapor-deposited thereon to a thickness of 250 nm in a ratio of 1:10 (ratio by weight). Finally, silver was vapor-deposited thereon to a thickness 300 nm (with degree of vacuum from 1.0×10^{-3} to 1.3×10^{-3} Pa) to form an EL device.

Measurement of External Quantum Efficiency

Using a source measure unit model 2400 manufactured by Toyo Corporation, DC constant voltage was applied to each of the EL devices thereby permitting them to emit light, and the luminance thereof was measured by a luminance meter BM-8 manufactured by Topcon Corporation. Further, the emission spectrum and emission wavelength were determined using a spectrum analyzer PMA-11 manufactured by Hamamatsu Photonics K.K. Then, the external quantum efficiency of the EL device was calculated from the measurements in accordance with the luminance conversion method.

As a result, a light luminance of 34 cd/m^2 was observed when a voltage of 20V was applied, and the external quantum efficiency was less than 0.1%.

Therefore, it is considered that the devices of the instant invention have unexpectedly higher external quantum efficiency than those of the EL devices of Example 1 described in Akiyama et al., and the instant invention and the invention described in Akiyama et al. are quite different.

DIFFERENCE IN EMISSION MECHANISMS BETWEEN THE INSTANT
INVENTION AND AKIYAMA ET AL.

In an organic EL device, the ratio of singlet excitons to triplet excitons generated in a host material in a light-emitting layer by charge recombination is 1:3.

In the case of a general fluorescent-emitting organic EL device, fluorescence is only emitted from the singlet excitons, and the triplet excitons do not contribute to emission.

Therefore, the internal quantum efficiency in the fluorescence has an upper limit of 25%.

Emission Mechanism of the Instant Invention

In an EL device, the energy of singlet excitons (S_1) generated in a host material by charge recombination transfers to a fluorescent material directly (Forster transport) or via singlet excitons of an amplifying agent, thereby producing singlet excitons of the fluorescent material. The energy of the triplet excitons (T_1) generated in the host material transfers to the amplifying agent through the Dexter energy transport path, thereby producing triplet excitons of the amplifying agent. Then, the energy of the triplet excitons of the amplifying agent transfers to a fluorescent material through the Forster energy transfer path, thereby producing single excitons of the fluorescent material. In other words, since all of the energy of the singlet excitons and triplet excitons generated in the host material transfers to the fluorescent material, the internal quantum efficiency of the EL device may be

theoretically improved up to 100%.

Emission Mechanism of Akiyama et al.

In the case of the organic EL device according to the first embodiment:

The singlet excitons (S_1) and the triplet excitons (T_1) at a ratio of 25%:75% were formed by the first organic compound. Then the singlet excitons shift to the triplet excitons by the intersystem crossing, and the ratio of the triplet excitons increases to more than 75%. Energy transfer may occur from the triplet excitons of the first organic compound to the higher order triplet excitons of the second organic compound through the Dexter energy transport path. The generated higher order triplet excitons (T_n) of the second organic compound produce the singlet excitons of the second organic compound by the reverse intersystem crossing, and fluorescence of the second organic compound is emitted.

In the case of the organic EL device according to the second embodiment:

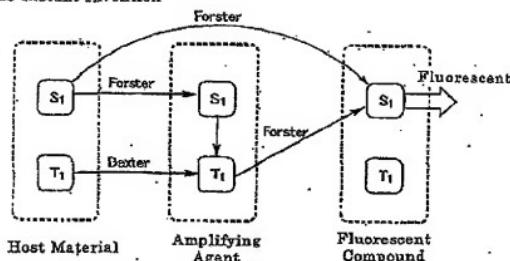
The third organic compound (corresponding to a host material) is electrically excited and forms singlet excitons and triplet excitons at a ratio of 25%:75%. The energy of the singlet excitons transfers to the first organic material (corresponding to an amplifying agent) through the Forster energy transfer path, thereby producing the singlet excitons of the first organic material.

On the other hand, the energy of the triplet excitons generated in the third organic compound transfers to the first organic compound through the Dexter energy transfer path, thereby producing triplet excitons of the first organic

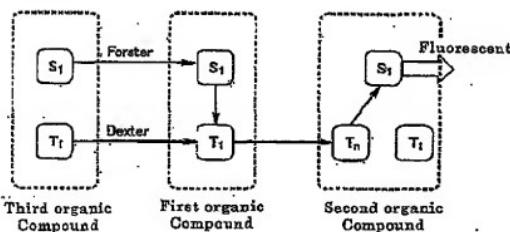
material. Thereafter, the singlet excitons of the second organic compound were produced in a similar mechanism as the first embodiment, and fluorescence of the second organic compound is emitted.

Therefore, the process producing the excited single state of the fluorescent material by the intersystem crossing in Akiyama et al. and the process producing by energy transfer from the amplifying agent in the instant invention are quite different.

Emission Mechanism of
the Instant Invention



Emission Mechanism of
Akiyama et al.



CONCLUSION

It is clarified that the presently claimed invention is quite different from the invention described in Akiyama et al. and produces unexpected improvements in external quantum efficiency.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: August 25, 2008

Toshihiro Ise.

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